AMENDED SPECIFICATION

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PATENT SPECIFICATION

851,473

DRAWINGS ATTACHED

851,473

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International Classification:—B29c, d.

COMPLETE SPECIFICATION

Treatment of Flexible, Thermoplastic, Organic Polymeric Sheets and Films

We, THE KENDALL COMPANY, a Corporation organized and existing under the laws of the State of Massachusetts, United States of America, of Boston, State of Massachusetts, United States of America, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a method and apparatus for providing perforations in flexible, polymeric, organic, thermoplastic sheets and films. The method and apparatus according to the invention may be applied to sheets of polymeric materials, such for example as polyethylene terephthalate, having a crystalline structure to provide therein not only perforations but also localized heat-sealable areas of amorphous structure. Thus the sheet may be a flexible sheet of chemically homogeneous crystalline thermoplastic organic polymeric material having, on at least one surface thereof, localized heat-sealable areas forming an integral part of the sheet, said localized areas having a lower thermal softening temperature than and being less crystalline than the remainder of said surface. Such a sheet is claimed in our copending Application of even date, No. 68/57 (Serial No. 851053). The invention is, however, also applicable to the perforation of sheets of polymeric materials, such for example as polyethylene, which cannot exist in the amorphous state at room temperature. While the invention is primarily concerned with the perforation of flexible sheets in the form of continuous films, the expression "sheet" as used herein is to be understood as including not only a continuous film but also sheeted material composed of fibres of a thermoplastic polymeric material integrated into sheet form, for example by weaving, knitting, moulding, carding or by paper making methods.

The invention provides a method of perforating a sheet of flexible, thermoplastic, organic, polymeric sheet material which comprises melting and perforating the material of the sheet at selected localized areas thereof by subjecting the sheet to the action of hot fluid while simultaneously cooling other areas of the sheet to prevent those other areas from melting.

Preferably the sheet is moved relatively to a stream of hot fluid while in contact with a cooled perforated supporting surface which moves with the sheet, the hot fluid producing perforations in the sheet in register with the perforations in the supporting surface.

When the sheet is a continuous film of thermoplastic polymeric material, the molten material displaced during formation of the perforations accumulates in raised beads surrounding the perforations.

The invention includes apparatus for carrying out the method just described comprising a perforated heat-conductive surface for supporting the sheet to be treated, means for cooling the supporting surface, means for directing a stream of hot fluid on to the exposed surface of the sheet on the supporting surface and means for providing relative

motion between the supporting surface and the stream of hot fluid in a direction transverse to the direction of the stream.

The invention will now be described in more detail, by way of example, with reference to the accompanying drawing, in which:—

Fig. 1 is a plan view of part of a sheet of thermoplastic material perforated by the method of the invention,

Fig. 2 is a highly enlarged perspective view of part of the sheet shown in Fig. 1,

Figs. 3—6 are enlarged sectional views showing successive stages in the formation of a perforation in the sheet and

Fig. 7 is a diagrammatic view of an apparatus for carrying the method of the invention into practice.

The apparatus shown in Fig. 7 includes a reel 51 of thermoplastic sheet material in the form of a continuous film which is fed, as indicated at 52, over a hollow rotating metal cylinder 53, the peripheral surface of which is provided with perforations of the desired dimension and pattern and the film 52 then passes to a take-up roll 54. Opposite the cylinder 53 there is provided means for directing a jet of heated air on to the surface of the film 52 passing over the cylinder. The jet is so formed that it may be efficiently heated as by a gas flame from a burner 56. The air is directed through the jet orifice 57 under pressure supplied through the pipe 58. A cooling jet 60 is directed against the back surface of the cylinder 53.

Operation of the apparatus shown in Fig. 7 may be varied according to the particular type of sheet desired. The temperature of the hot air jet must be such as to at least insure melting of the areas of the sheet opposite the perforations in the cylinder 53 during its passage through the air jet. The velocity of the jet should be taken into consideration in connection with the speed of the sheet and the temperature of the jet, the faster the jet velocity the lower the temperature for a given speed of film operation.

Jet temperatures as low as the melting point of the material being treated may be used. However, jet temperatures from 260° C. to 875° C. with film speeds running from 4 to 33 yards per minute, depending upon the particular film, are preferred. The grid sizes used in the case of circular holes have varied from 2 mils to 1/4 inch in diameter. Obviously the range can be extended.

In the case of 1/4 mil polyester film sold under the Registered Trade Mark "Mylar", the jet orifice was 25 mils wide and 9 inches long, the gauge air pressure was about 30 pounds per square inch, the cylinder 53 was approximately 4 inches in diameter and in one case, for example, contained about 237 holes per square inch on uniformly spaced centres affording an open area of approximately 21% with each hole being approximately 33 mils in diameter. The temperature of the air as it issued from the jet was approximately 370° C. At this temperature, the film 52 was fed through the apparatus at approximately 7 yards per minute, the space between the orifice and the grid roll being approximately 1/4 inch (show proportionately enlarged in Fig. 4). The cooling jet 60 is preferably operated to maintain the surface of the cylinder 53 at approximately 55 to 70° C.

When treating 3/4 mil film of the vinylidene chloride-vinyl chloride copolymer sold under the registered trade mark "Saran", the same cylinder, the same distance from cylinder to orifice and the same jet orifice were used as those described above in the case of "Mylar" polyester film, but the gauge air pressure was 18 pounds per square inch with the temperature of the air as it issued from the jet approximately 235° C. The film in this instance was fed through the apparatus at approximately 1.7 yards per minute with the cooling jet maintaining the surface of the cylinder in the same range of temperature as described above for the "Mylar" polyester film.

When treating film of the monochlorotrifluoroethylene polymer sold under the registered trade mark "Kel-F" in 2 mil thickness, the orifice size was changed to 35 mils wide by 5 inches long, the distance from cylinder to orifice was reduced to 1/8 inch and a 4" diameter cylinder with holes approximately 250 mils in diameter and 8 holes per square inch was used. The gauge air pressure was 35 pounds per square inch, while the temperature of the air as it issued from the jet was approximately 425° C. The film in this instance was fed through the apparatus at approximately 2 yards per minute with the cooling jet maintaining the surface of the cylinder at approximately 105° C.

As the result of the treatment, the film of thermoplastic material is perforated as indicated at 20 in Fig. 1, the disposition of the perforations being determined by the disposition of the perforations in the surface of the cylinder 53, the portions 22 of the body of the sheet being cooled by the cylinder as indicated at 22. As shown in Fig. 2, each perforation 20 is toroidal in shape and has an annular bead 24 encircling the perforation 26. The beads 24 serve to reinforce the edges of the perforations.

The perforations may be extremely minute. For example, the film of Figs. 1 and 2, having for example a 1/4 mil caliper in the areas 22 may contain perforations slightly less than 20 mils in minimum diameter, and so closely spaced as to provide 714 holes or more per square inch. This example is by no means the ultimate, however, since in very small samples as many as 4,000 holes per square inch of 8 mils diameter each have been made and on

an individual basis, holes as fine as 2 mils have been produced.

Figs. 3 to 6 represent the successive effects of application of heat to the material of the sheet overlying the perforations in the cylinder 53. This series of figures shows, first the rupture of the material centrally followed by a progressive displacement of the material towards the unmelted areas surrounding the perforation, and taking in general the successive forms of bead-like borders, culminating in the bead 24 depicted in Fig. 6.

WHAT WE CLAIM IS:—

1. A method of perforating a sheet of flexible, thermoplastic organic polymeric sheet material which comprises melting and perforating the material of the sheet at selected localized areas thereof by subjecting the sheet to the action of hot fluid while simultaneously cooling other areas of the sheet to prevent those other areas from melting.

2. A method as claimed in Claim 1, wherein the other areas of the sheet are prevented from melting by cooling the side of the sheet remote from that exposed to the hot fluid.

3. A method as claimed in Claim 2, wherein the sheet is moved relatively to a stream of hot fluid while in contact with a cooled perforated supporting surface which moves with the sheet, the hot fluid producing perforations in the sheet in register with the perforations in the supporting surface.

4. A method as claimed in Claim 3, wherein the sheet is caused to travel on the peripheral surface of a hollow rotating cylinder of heat conductive material having perforations in said peripheral surface, the cylinder traversing the sheet zone by zone through the stream of hot fluid and also traversing a stream of coolant, the stream of hot fluid being directed against a portion of the sheet which is in contact with the cylinder and the stream of coolant being directed against a portion of the periphery of the cylinder which is not covered by the travelling sheet.

5. A method as claimed in Claim 4, in which the stream of hot fluid is a jet of heated air.

6. A method as claimed in Claim 3, wherein the perforations formed in the sheet are minute and only minutely separated from one another.

7. A method as claimed in any preceding claim, wherein the sheet is a continuous film and each perforation is surrounded by a raised bead.

8. Apparatus for carrying out the method claimed in claim 3, comprising a perforated heat conductive surface for supporting the sheet to be treated, means for cooling the supporting surface, means for directing a stream of hot fluid on to the exposed surface of the sheet on the supporting surface and means for providing relative motion between the supporting surface and the stream of hot fluid in a direction transverse to the direction of the stream.

9. Apparatus as claimed in Claim 8, wherein the supporting surface is the outer surface of the perforated peripheral wall of a rotatable hollow cylinder and including a reel from which the sheet is fed continuously around part of the circumference of the cylinder to a take-up roll.

10. Apparatus as claimed in Claim 9, including a cooling jet directed against the exposed surface of the cylinder.

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1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

Fig. 1.

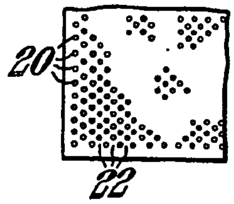

Fig. 2.

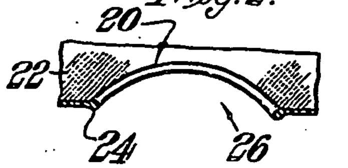

Fig. 3.

Fig. 4.

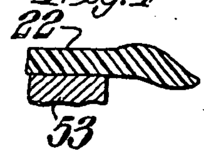

Fig. 5.

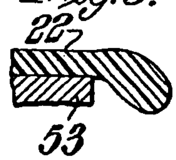

Fig. 6.

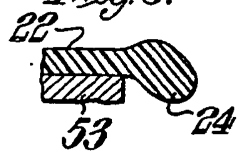

Fig. 7.